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ABSTRACT

Research has revealed interactive effects of school size and socioeconomic status--as school size increases, the mean measured achievement of schools with disadvantaged students declines. The larger the number of less advantaged students attending a school, the greater the decline. The same school-level interactions have been found in California, West Virginia, Alaska, Montana, Ohio, Georgia, and Texas. To improve on past research, this study, involving 1,001 Texas high schools, has controlled for more variables, namely ethnic, linguistic, socioeconomic, size, cost, and curricular composition factors. Results affirm the previous research results, giving the finding of this interactive effect a degree of consistency that is rare in educational research. This study also examined the claim that large schools with a narrow range of grades necessarily save money by achieving economies of scale. Results indicate that school size was negatively related to costs, but this relationship became increasingly tenuous as school size increased, with savings eventually becoming negligible. In addition, analysis of organizational factors distinct to the single-unit school indicates that if schools are designed solely to minimize expenditure per pupil, the best configuration may be a large single-unit school. However, if expenditure per pupil is balanced with achievement-based equity, the best configuration seems to be one small single-unit school per district. While decreased size would increase costs, the fact that there is only one school with 13-15 grade levels would substantially diminish costs. (Contains 69 references.) (TD)

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HIGH SCHOOL SIZE, ACHIEVEMENT EQUITY, AND COST: ROBUST INTERACTION EFFECTS AND TENTATIVE RESULTS

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ABSTRACT

The past decade has occasioned a dramatic increase in research on relationships between school size and a variety of outcomes, including measured achievement, high school completion rates, and postsecondary enrollment rates. An interesting interaction effect which has been found in replications across seven very different states is that as school size increases, the achievement test score costs associated with economically disadvantaged students also increases. In short, as schools get larger, average achievement among low socioeconomic status students suffers. A traditionally strong argument against smaller schools, however, is that they are too expensive. Large consolidated schools with narrowly specialized grade spans are typically offered as necessary to save money and to meet the needs of different age groups. In this paper, we have two objectives. First, to determine if the size-by-socioeconomic status interaction effect proves robust across alternative regression model specifications, as it did across different states. Second, to make a tentative judgment as to whether the equity gains associated with smaller schools are incompatible with the need to save money.

Educational researchers and policy makers rarely meet an issue they are willing to resolve once and for all. School size is a case in point.

Interest in school size as an explanatory factor waxes and wanes, but never dies. The effect of variability in school size on educational achievement and a variety of related outcomes remains a subject of sometimes intense, sometimes dilatory disciplined inquiry and debate.

In the following, we use a Texas data set representing 1001 high schools to build on previous research, done first in California and then replicated in six very different states. This research has, with unusual consistency, found an interesting interaction effect: as school size increases, the mean achievement test score costs associated with students who are economically less-advantaged also increases. In short, as schools get larger, those with poor children as students do increasingly less well.

RESEARCH QUESTIONS

Continuing this line of research, we will address two specific questions. First, will replication with a more adequately specified regression model find the same size-by-socioeconomic status (size-by-SES) interaction effect among the high schools in our Texas data set? Second, whatever the merits of small schools, are large high schools with conventionally narrow grade ranges necessary to save money, or can cost savings occur without increased size?

REPLICATION THROUGH RE-SPECIFICATION

In previous analyses, the independent variables included in regression equations were limited to a measure of school size, either total number of students or number of students per grade level; a measure of SES, most often percent of students eligible for free or reduced cost lunch; and the multiplicative interaction term. The one exception is a multi-level analysis of Georgia data which also incorporated ethnic composition and student/teacher ratio (Bickel and Howley, 2000). To improve on past research, the primary difference between the work reported herein and previous replications is a more adequately specified regression model.

Therefore, we are now asking if the size-by-SES interaction effect will prove unduly sensitive to better-informed regression model specification, diminishing the credibility of the consistent results reported from previous research. In other words, was the interaction effect an artifact of specification error?

FISCAL PRACTICALITY

In addition, we examine the claim that large schools with a narrow range of grades are a necessary modern organizational consequence of the need to save money. Many who have persisted in off-handedly dismissing the small-is-better research have done so in the name of fiscal practicality. Large consolidated schools, specializing in just a few grade levels, are uncritically judged as essential for economies of scale, and to meet the differing needs of different student in different grades. To hold otherwise seems to many

a sentimental indulgence in nostalgic preference for a romanticized common school ideal. (For a more balanced view, see Boex and Martinez-Vasquez, 1998).

In our analyses, school size is negatively related to expenditure per pupil. However, our findings regarding the link between school size and cost are a good deal more complex than this commonplace finding suggests.

Specifically, one hundred sixteen of the high schools in our Texas data set are single-unit schools: the only school in a typically small, typically rural district, containing all elementary and secondary grades under one roof. With expenditure per pupil as the outcome measure, multiple regression analysis shows that single-unit schools, on average, correspond to a saving of 1017 dollars, when compared with conventionally grade-specialized high schools. (See Table 6.)

This saving can be statistically attributed to two distinctive characteristics of single-unit schools: each is the only high school in its district, and each has an unusually broad grade configuration, K-12, PreK-12, or early childhood-12. (See Table 7.) The savings corresponding to single-unit schools and their distinctive characteristics are diminished, however, as such schools become larger.

SCHOOL SIZE: A TIMELY ISSUE

Research on the role of school size as a determinant of school performance has a long history and has generated a voluminous literature (see, for example, Barker and

Gump, 1964; Guthrie, 1979; McDill, Natriello, and Pallas, 1986; Smith and DeYoung, 1988; Fowler, 1991; Walberg and Walberg, 1994; Khattari, Riley, and Kane, 1997). As with so many commonly invoked explanatory factors in the social and behavioral sciences, research on the effects of school size has, over the years, yielded conflicting findings (Rossmiller, 1987; Caldas, 1993; Lamdin, 1995; Rivkin, Hanushek, and Kain, 1998). As a consequence, school size sometimes has been relegated to the status of an obligatory but uninteresting control variable. Not infrequently, it simply has been ignored (Barr and Dreeben, 1983; Gamoran and Dreeben, 1986; Farkas, 1996; Wyatt, 1996; Hanushek, 1997 and 1998).

Uncertainty as to the import of school size has yielded state-of-the-art school effectiveness research which fails to designate size a "resource," much less a resource worthy of investigation. A recent school effectiveness review by eleven production function virtuosos, for example, devoted four of its three hundred ninety-six pages to school size (Hodges and Greenwald, 1996: 81; Betts, 1996:166-168). Consequences of variability in school size were, in sum, found to be uncertain.

One Size Fits All

One important limitation of most literature covering school size has been failure to examine the interaction of school size with other variables (Howley, 1989; Lee and Smith, 1995; Mok and Flynn, 1996; Riordan, 1997). This deficiency tends to give rise to a one-size-fits-all point of view. Within any school, it may seem, size-related benefits accrue and

size-related costs are borne equally by all students (Conant, 1959; Haller, 1992; Haller, Monk, and Tien, 1993; Hemmings, 1996).

Discounting Equity

In an era of cult-of-efficiency institutional restructuring, moreover, questions as to the best size for any school are often expressed in the scientific management terms of organizational efficiency. In economists' terminology, presumed economies of scale frequently have been given pride of place (Tholkes and Sederberg, 1990; Haller, Monk, Bear, Griffith, and Moss, 1990; Purdy, 1997). As with much contemporary educational research, equity questions have often been deemed largely irrelevant to the school size discussion. For many, this has come to mean bigger-is-better (Stevenson, 1996).

Small is Better?

Recently, nevertheless, attention has been drawn to a growing body of empirical research which holds that school size is negatively associated with most measures of educational productivity. This includes measured achievement levels, dropout rates, grade retention rates, and college enrollment rates (see, for example, Walberg and Walberg, 1994; Stevens and Peltier, 1995; Fowler, 1995; Mik and Flynn, 1996; Bickel and McDonough, 1997).

Size-by-SES Interaction Effects

In part, renewed interest in smaller schools is due to research concerning the joint or interactive, rather than independent or main, effects of school size and socioeconomic status. Specifically, interaction effects have been identified which suggest that the well known adverse consequences of socioeconomic disadvantage are tied to school size in substantively important ways.

In brief, as school size increases, the mean measured achievement of schools with less-advantaged students declines. The larger the number of less-advantaged students attending a school, the greater the decline (Friedkin and Necochea, 1988; Howley, 1989 and 1996; Bickel and Howley, 2000).

In addition to helping revive interest in school size as a variable of importance in educational research, this work has begun to sensitize researchers and policy makers to equity concerns associated with school size. One-size-fits-all is no longer a unanimous judgment. Some researchers and policy makers are now asking best-size-for-whom (Henderson and Raywid, 1994; Devine, 1996)?

REPRODUCIBLE FINDINGS: A RESEARCH AGENDA

Research on size-by-SES interactions, moreover, has substantial geographic scope. The same school-level interactions have been found in California (Friedkin and

Neccochea, 1988), West Virginia (Howley, 1989), Alaska (Huang and Howley, 1993); Montana (Howley, 1999a), Ohio (Howley, 1999b); Georgia (Bickel, 1999a), and Texas (Bickel, 1999b). In contrast to so much research which has yielded initially interesting findings, the likelihood that further replication will yield sharply conflicting results has been systematically addressed and diminished.

Texas High School Data for 1996-97

By way of continuing this line of investigation, we use a data set consisting of 1001 Texas high schools. This represents 83.6 percent of all high schools in the state for academic year 1996-97. The 196 excluded schools are those for which values were not available for one or more of the variables used in our analyses (Bickel, 1999b).

Independent Variables

As already explained, previous research on this issue has been marked by unduly simplified regression model specification. In part, this is because proper specification for research on school size or any other correlate of achievement is substantively uncertain and theoretically thin (Howley, 1995; Hanushek, 1996).

The independent variables included in Table 1, however, seem well suited to our analysis of Texas high schools. They reflect the ethnic, linguistic, and socioeconomic diversity of the state's high school students (PCTBLACK, PCTHISP, PCTLEP, PCTPOOR); they show substantial variability in Texas high schools' organizational

characteristics and resources, including size (SIZE, S/TRATIO, EPP, PCTINST, UNIT, LEVELS, HIGHSKLS); and they manifest pertinent variability in curricular composition (PCTTECH, PCTSPECL, PCTGIFT).

Inclusion of student/teacher ratio (S/TRATIO), a useful proxy for class size, among the added independent variables enables us to address questions as to whether small classes in large schools diminish the adverse consequences of bigness. As it turns out, they do not.

TABLE 1 ABOUT HERE

Dependent Variables: Measures of Achievement

In Tables 3, 4, and 5, the dependent variables are taken from the mandatory Texas Assessment of Academic Skills (TAAS) end-of-grade battery, used on a limited basis since the Fall of 1990, and fully implemented in 1994. The tests are criterion-referenced measures of attainment in reading, math, and writing, administered to tenth graders throughout the state, and used to evaluate the performance of students and, by implication, the effectiveness of schools and school districts in promoting measured achievement. Measures of internal consistency for the TAAS tests are reported to range from .80 to .90 (Texas Education Agency, 2000). (For critical discussions of the use and

interpretation of TAAS, see Clopton, Bishop, and Klein ,1997; Haney, 2000; and Klein, Hamilton, McMaffery, and Stecher, 2000).

Dependent Variables: Expenditure Per Pupil

In Tables 6 and 7, expenditure per pupil is the dependent variable, and measured achievement is used for purposes of statistical control rather than as an outcome measure. Since scores for R10, M10, and W10 are closely correlated, use of all three in the same equation produces multicollinearity, with Condition Indices well above thirty (Gujurati, 1995: 338).

To remedy this, we have created a summary achievement measure, COMPOSITE, which is the sum of the Z scores of R10, M10, and W10. All bivariate correlations between COMPOSITE and its three constituents exceed .935.

We have also found that the relationship between SIZE and EPP is curvilinear, but that the relationship can be linearized using natural logarithms of SIZE. This is discussed further below.

Descriptive Statistics

Table 2 shows us that the mean value for SIZE, number of students, is 877.19. The size of the standard deviation, 849.88, indicates that SIZE manifests a good deal of variability, with a coefficient of variation of 103.2 percent.

While SIZE has a positive skew, the skew is not so extreme that the variable warrants logarithmic or other transformation (Fox, 1997: 64-68). In fact, using the Studentized range test for normality, SIZE more closely approximates a normal distribution when non-transformed values are used (see Kanji, 1993: 65). Therefore, actual SIZE values are used in the analyses with achievement tests as outcome measures, reported in Tables 3, 4, and 5.

However, the relationship between SIZE and EPP is curvilinear: concave and sloping downward for the smallest values of school size; almost perfectly straight with a modest downward slope for SIZE values between 220 and 550; almost perfectly straight with a diminished downward slope between size values 550 and 1800; then sloping still less, and eventually becoming level for SIZE values of more than 3200 students. This is similar to the curvilinear relationship between high school size and cost which Stiefel, Berne, Iatarola, and Fruchter (2000) found with their New York City data.

We have linearized the relationship between SIZE and EPP in our Texas data by taking natural logarithms of SIZE for the analyses reported in Tables 6 and 7.

TABLE 2 ABOUT HERE

Means and standard deviations for PCTBLAK, PCTLEP and HIGHSKLS are reported in Table 2 before the variables were logged. Since, however, each has a sharp positive skew, with most of the observations confined to a very narrow range of data on the left side of the distribution, the variability of each is tightly constrained. Taking natural logarithms spreads each distribution, making it more informative (Fox, 1997: 64-68).

It is also worth noting that the standard deviations for the R10, M10, and W10 achievement tests are small: 2.30, 4.08, 1.80. Coefficients of variation are similarly small, 5.9, 9.0 percent, and 5.5 percent.

Regression Results: A Robust Interaction Effect

Tables 3, 4, and 5 provide results of regression analyses using TAAS reading, math, and writing scores as dependent variables. The most interesting finding for present purposes is that the size-by-SES interaction effect is statistically significant and negative in each instance. This means that as school size increases, the mean achievement test score costs associated with economically less-advantaged students increases, as well. This, of course, was the finding in all previous replications.

TABLE 3 ABOUT HERE

TABLE 4 ABOUT HERE

TABLE 5 ABOUT HERE

Clearly, the interaction effect involving school size and the percentage of students who are poor is robust and strong in the presence of regression model re-specification. This adds credibility to the repeatedly replicated finding that smaller schools diminish the achievement disadvantages associated with being poor. Larger schools, by contrast, exaggerate these disadvantages.

Effect Size

As with previous research on size-by-SES interactions, we have computed effect sizes by using partial derivatives. This is done by differentiating the regression equations in Tables 3 through 5 with respect to SIZE (expressed in thousand-student units), while treating the other independent variables as constants (Purcell and Varberg, 1984: 308-309 and 636-639). Statistically nonsignificant coefficients are set equal to zero.

The results, reported at the bottom of each table, are the average achievement decrements, in test score points and standard deviation (S.D.) units, which come with each quartile increment in PCTPOOR. In each instance, we see that there are mean

achievement test score costs associated with economically disadvantaged students, and these costs increase as the percentage of less-advantaged students increases.

The substantial nature of the achievement costs becomes clearer when we recall that the standard deviations and coefficients of variation for R10, M10, and W10 are small. Again, this replication, based on informed regression model re-specification, makes clear that the size-by-SES interactions are robust and strong.

CAN COSTS DECLINE WITHOUT INCREASING SIZE?

In spite of the foregoing, small schools with a broad range of grade levels seem singularly anachronistic. The move toward ever-larger, ever-more grade specialized schools, is proceeding apace (Lyons, 1999; Funk and Bailey, 1999; Boex and Martinez-Vasquez, 1998).

Research such as that reported above may be of growing interest to researchers and policy analysts. Administrators and policy makers, however, are forced to deal with tight budgetary constraints. For them, cost remains a primary consideration. Departure from the large, grade-specialized mode in pursuit of equity is, in many instances, "a luxury they cannot afford" (Keller, 2000).

Multiple Regression Analysis: Expenditure Per Pupil

In the regression analysis reported in Table 6, the dependent variable is expenditure per pupil. The independent variables are otherwise the same as with Tables 3, 4, and 5, except that the size-by-SES interaction term has been deleted as irrelevant to this analysis, and the three achievement test scores are now used for purposes of statistical control, combined in the COMPOSITE variable.

In addition, an independent variable (not shown in the tables) has been added to control for grade level differences in expenditure per pupil. This weighting variable was created by multiplying the number of students at each grade level by the mean EPP at each grade level, summing across the grades included in a school, then dividing by school size. Without this control variable, the fact that lower grades have lower average EPP could lead to exaggerated attributions of cost reductions for schools with the broadest range of grades, including more than the usual 9-12 high school grade span.

Finally, a multiplicative interaction term created using UNIT and SIZE (with SIZE logged and centered) has been added. Given statistically significant coefficients for these two variables, a UNIT-by-SIZE interaction term will enable us to determine if the relationship between SIZE and EPP varies from single-unit schools to conventional high schools.

TABLE 6 ABOUT HERE

Regression Results: Anticipated and Unanticipated Findings

Not surprisingly, school size (SIZE) has a statistically significant and negative relationship to expenditure per pupil. The same is true of student-teacher ratio (S/TRATIO), the variable exercising the greatest influence on expenditure per pupil.

Less predictably, notice the negative, statistically significant regression coefficient corresponding to UNIT. According to these results, a single-unit school is associated with an average reduction in expenditure per pupil of just over 1017 dollars. This holds with our complete complement of controls in place. Other things being equal, having only one school, covering all grades in a district, represents substantial dollar savings.

The multiplicative interaction term, UNIT-by-SIZE, however, also has a negative and statistically significant coefficient. This means that increases in school size yield greater cost reductions for single-unit schools than for conventional schools.

Reduced Costs Without Increased Size?

The results reported in Table 6 affirm that size is negatively related to expenditure per pupil, for both single-unit schools and conventional high schools. It is also clear,

however, that the relationship is more complex than commonly acknowledged. Why, for example, after controlling for size and a reasonable complement of other factors, should single-unit schools be associated with substantial savings in expenditure per pupil? Furthermore, why should increases in size yield greater cost reductions for single-unit schools than for conventional grade-specialized schools?

Single-Unit Schools: Organizational Distinctiveness

Organizationally, the characteristics which conspicuously set single-unit schools apart are number of grade levels, and the fact that each is the only school in its district. Seventy-five percent of the high schools in our data set have four or fewer grades (LEVELS). Single-unit schools, however, with K-12, PreK-12, or early childhood-12 configurations, have thirteen, fourteen, or fifteen grade levels.

Similarly, the mean of the variable HIGHSKLS (before logging) tells us that the average number of high schools per district is nearly three, while a single-unit school is the only school of any kind in its district.

Single-Unit Distinctiveness and Expenditure Per Pupil

In an effort to explain cost savings associated with single-unit schools, therefore, in Table 7 we have added two additional independent variables, representing the distinctive characteristics of single-unit schools. Since LEVELS is very closely correlated with UNIT

(r=.965), the UNIT variable has been deleted, replaced by the factors which define single-unit schools.

LEVELS and HIGHSKLS (with HIGHSKLS logged) are here treated as essential components of the global, complex variable UNIT (Rosenberg, 1968: 40-52). In effect, we are trying to identify the specific characteristics of UNIT which account for its unexpected relationship with expenditure per pupil. These same characteristics, of course, may also be associated with reduced costs in conventional high schools.

In addition, a multiplicative interaction term has been created with SIZE and each of the components of UNIT. Thus, we are also adding to the regression equation LEVELS-by-SIZE and HIGHSKLS-by-SIZE, with all variables used in creating the interaction terms centered.

TABLE 7 ABOUT HERE

LEVELS, HIGHSKLS, and Expenditure Per Pupil

The results are instructive. Predictably, as with Table 6, the coefficients corresponding to SIZE and S/TRATIO are negative and statistically significant. This holds in spite of the fact that SIZE and S/TRATIO are closely correlated (r=.736), thereby reducing statistical power. However, the variance inflation factors for each, though the

largest for the equation, are well within acceptable limits, 4.870 and 4.131 (Chatterjee, Hadi, and Price, 2000: 240-241).

Furthermore, given that LEVELS and HIGHSKLS are construed as effective components of UNIT, the following are not surprising: as the number of high schools in a district increases, expenditure per pupil also increases, averaging just over 332 dollars per school. In addition, each grade level added to a high school is associated with an average expenditure per pupil decrease of just over 98 dollars. (The distribution of high schools per district and by grade levels are reported in Table 8 and Table 9.)

TABLE 8 ABOUT HERE

TABLE 9 ABOUT HERE

Finally, the statistically significant interaction terms make clear that as SIZE increases, the increased costs associated with having more than one high school in a district are diminished; while the reduced costs associated with having more grade levels are reduced still more.

WHAT ARE WE TO MAKE OF ALL THIS?

School Size and Expenditure Per Pupil: Diminishing Returns

One way to summarize these complex results is to refer to effect sizes reported on Tables 6 and 7. For each analysis, as school size increases, the partial derivatives show savings, but progressively diminished savings. Yes, school size is negatively related to expenditure per pupil, but savings diminish with each increment in size.

School Size and Expenditure Per Pupil: Single-Unit Schools

Furthermore, with a judiciously selected complement of controls in place, single-unit schools and their defining characteristics, number of grade levels and uniqueness in their district, are associated with substantial savings in expenditure per pupil. For these organizationally distinctive schools, moreover, size contributes more to reducing costs than for conventional high schools. It remains true, however, that for single-unit schools, also, diminution in expenditure per pupil slows as school size increases.

School Size and Expenditure Per Pupil: HIGHSKLS and LEVELS

Not surprisingly, given the savings associated with single-unit schools, as the number of schools in a district increases, so does expenditure per pupil, though this cost is diminished for larger schools. Before construing this as an endorsement of

consolidation, however, recall that ever-larger size assures ever-diminishing returns with regard to expenditure per pupil. Furthermore, consolidated schools have conventionally narrow grade spans, and we have found that as the number of grade levels in a school increases, expenditure per pupil is again diminished.

A Tentative Explanation: Diseconomies of Scale

Typically, economists attribute diseconomies of scale to problems posed by the need for coordination and control (Friedman, 1990; Boex and Martinez-Vasquez, 1998). This follows from different interests among organizational participants, including lack of consensus with regard to organizational objectives. The usual response is a system of personnel and procedures for supervision and monitoring.

Supervision and monitoring, however, are costly. and these costs are increased by the need to coordinate and control those who supervise and monitor. As organizations become larger and more complex, with ever-greater specialization among employees, departments, and levels, threats of organizational anomie and anarchy exaggerated (Shedd and Bachrach, 1991). This increases supervision and monitoring costs to unacceptably high levels.

In schools, it may be, that inclusion of all grade levels in the same setting fosters a common understanding of the organization's purpose. A K-12 school, for example, includes all personnel who teach and administer in all grades in the same location. This may prevent development of the usual articulation problems which characterize

relationships among elementary schools, middle schools, and high schools, diminishing the need for costly monitoring and supervision.

Similarly, if a school is the only one in its district, between-school differences in purpose and procedure cannot occur, further reducing the need for coordination and control through monitoring and supervision. When a single school with a broad range of grade levels is also small, the seemingly antithetical goals of saving money and promoting equity in achievement may be attained simultaneously.

This tentative account, of course, shifts our focus from schools to school districts. This is consistent with earlier Georgia research, in which we found that the achievement of less-advantaged students in large schools was diminished less if the school was in small districts. In addition, we found that the expected achievement gains of less-advantaged students in small schools were undercut in large districts (Bickel and Howley, 2000).

SIZE-BY-SES AND COST

Table 10 joins the size-by-SES and cost issues still more closely together. We use the same regression model specification employed in Table 7. Our achievement composite is now the outcome measure, and we reintroduce the size-by-SES interaction term.

TABLE 10 ABOUT HERE

Interestingly, LEVELS, the component of UNIT which was associated with reduced expenditures, is now associated with increased achievement. HIGHSKLS, the component of UNIT which was associated with increased expenditures, is now associated with decreased achievement.

In most other respects the results in Table 10 are like the results reported in Tables 3, 4, and 5. Once again, the size-by-SES interaction term is statistically significant and negative, and the effect sizes demonstrate that as school size increases, the presence of economically disadvantaged students is associated with diminished average achievement.

CAUTIONARY COMMENTS

Our data set contains a large number of cases and a broad range of pertinent variables. Nevertheless, it is useful to bear in mind that Texas is a distinctive state. As such, our analysis is limited in specific ways.

Model Specification

Misleading results due to specification error are a good deal less threatening in our achievement analyses than in our analyses of expenditure per pupil. The size-by-SES interaction effect has proved robust across seven very different states, and for at least four different regression model specifications, two in this paper alone. (Compare Tables 3, 4, and 5 with Table 10. Also see Friedkin and Neccochea, 1988, Huang and Howley, 1993; Howley, 1995; Howley and Bickel, 1999; Bickel and Howley, 2000).

Misleading results due to specification error are more likely in our analyses of expenditure per pupil because the variables we have found to be especially interesting, UNIT, LEVELS, and HIGHSKLS, as well as the interaction effects created with SIZE, are under-researched.

The research that has been done on these issues, moreover, does not address relationships between expenditure and variables such as UNIT, LEVELS, and HIGHSKLS (see Wihry, Coladarci, and Meadow, 1992; Alspaugh, 1996; Howley and Harmon, 1996; Franklin and Glascock, 1998). Therefore, though our choice of independent variables and functional forms seems reasonable, we acknowledge that our regression model specification is tentative, and that a better-informed alternative may yield different results.

Concepts: Single-Unit School

We have defined single-unit schools as the only school in a district, including all grade levels. The performance of the component variables LEVELS and HIGHSKLS, along with interaction effects created with these variables and SIZE, suggests that there is merit to this way of construing the single-unit school and its distinctive components.

However, in the only national survey of single-unit schools, Howley and Harmon (1996) suggest that the single-unit designation be applied to any K-12 school, whether or not it is the only school in its district. In Texas, however, each K-12, PreK-12, and early childhood-12 school is the only school in its district. In a real sense, as we have seen, Texas single-unit schools are <u>districts</u> as well as schools.

Nevertheless, as Howley and Harmon (1996) make clear, this is not the case in all states. The uniqueness-in-district that we have construed as a defining characteristic of single-unit schools in Texas may not characterize single-unit schools elsewhere. Our tentative account of why achievement equity and cost saving can be simultaneously obtainable objectives suggests that having more than one single-unit school in a district would diminish its attractiveness.

Concepts: Expenditure Per Pupil

We have measured cost in terms of expenditure per pupil. Funk and Bailey (1999), however, in their Nebraska research, judged cost per graduate to be a superior measure of cost efficiency. After all, one virtue of smaller school size is a lower dropout rate.

Similarly, Stiefel, Berne, Iatarola, and Fruchter (2000) measured cost in terms of total budget per pupil and total budget per graduate. Neither measure revealed the cost inefficiencies commonly attributed to small schools.

Whatever the virtues of per-graduate measures, their calculation requires dropout data which covers all grades in the schools being analyzed (Stiefel, Berne, Iatrola, and Fruchter, 2000: 33). Twenty-five percent of our Texas high schools, however, have five or more grades, and information on dropouts is often not reported for lower grades. Our choice of the traditional expenditure per pupil measure, therefore, was dictated by the information available in our Texas data set.

Multi-Level Analysis?

With the individual high school as the unit of analysis, an obvious strategy would be to do a multi-level analysis, with school districts constituting the second level. As it turns out, however, while only 11.6 percent of the schools are of the single-unit variety, 72.6 percent of the districts have only one high school. This yields an average within-group

sample size of 1.27. Schools and districts are thoroughly confounded in the organizational structure of public secondary education in Texas.

In addition, Singer (1987) has shown that with small within-group sample sizes, and small residual intra-class correlations, standard errors of regression coefficients are diminished very little by intra-class correlation, and tests of significance are reliable. In all our analyses, deflation of standard errors due to intra-class correlation is less than two percent (Singer, 1987: 224-226).

CONCLUSIONS

As with seven previous analyses, we have found that as school size increases, achievement test score costs associated with having economically disadvantaged students in schools increase, as well. This finding has now proven robust across seven states and at least four different regression model specifications. This degree of consistency is rare, indeed, in educational research.

We have also found that, while administrators and policy makers are correct in their judgment that school size is negatively related to costs, that is far from the whole story, at least with regard to expenditure per pupil. The negative relationship between size and expenditure per pupil becomes increasingly tenuous as school size increases, and eventually savings become negligible.

In addition, organizational factors, especially as manifest in the distinctive components of the single-unit school, reveal unanticipated relationships to cost reduction. If we were designing schools solely to minimize expenditure per pupil, the best configuration might very well be a large single-unit school.

However, if we were interested in balancing expenditure per pupil with achievement-based equity, the best configuration seems to be a small single-unit school. While decreased size would increase costs, a value of 1 on HIGHSKLS and a value of 13 to 15 on LEVELS would substantially diminish costs.

Our findings with regard to size and achievement have proven to be unusually robust and difficult to dismiss. Our findings with regard to ways to reduce school costs without increasing size are much more tentative, as is our explanation of these findings. Nevertheless, in pursuit of the seemingly antithetical aims of achievement-based equity and fiscal constraint, they seem worthy of additional investigation.

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TABLE 1
Definitions of Variables

SIZE	Number of students. (Expressed in thousand-student units in Tables 3 through 5; expressed in natural logarithms of single-student units in Tables 6 and 7.)
PCTPOOR	Percentage of students eligible for free or reduced-cost lunch.
PCTBLACK	Percentage of students who are Black. (Expressed in natural logarithms.)
PCTHISP	Percentage of students who are Hispanic.
PCTLEP	Percentage of students classified as limited English proficient. (Expressed in natural logarithms.)
S/TRATIO	Student/teacher ratio.
EPP	Expenditure per pupil. (Expressed in thousand-dollar units in Tables 3 through 5.)
PCTINST	Percentage of total budget allotted for instruction.
PCTTECH	Percentage of students enrolled in a full-time career and technical education curriculum.
PCTSPECL	Percentage of students enrolled in a full-time special education program.
PCTGIFT	Percentage of students classified as gifted.
UNIT	Coded 1 for single-unit schools, and 0 otherwise.
HIGHSKLS	Number of high schools in a district. A high school is any school which includes grade 12. (Expressed in natural logarithms.)
LEVELS	Number of grade levels.
R10	Texas Assessment of Academic Skills tenth grade reading test.
M10	Texas Assessment of Academic Skills tenth grade math test.
W10	Texas Assessment of Academic Skills tenth grade writing rest.

TABLE 2
Descriptive Statistics
Means and (Standard Deviations)

SIZE	877.19
	(849.88)
PCTPOOR	36.51
	(30.93)
PCTBLACK	11.07
	(17.34)
PCTHISP	27.73
	(27.78)
PCTLEP	4.95
	(8.99)
S/TRATIO	13.24
	(3.15)
EPP	4745.67
	(1318.94)
PCTINST	69.92
	(7.34)
PCTTECH	56.12
	(20.59)
PCTSPECL	13.54
	(6.08)
PCTGIFT	9.02
	(7.07)
UNIT	0.12
	(0.32)
HIGHSKLS	2.96
	(5.12)
LEVELS	5.34
	(3.11)
R10	39.17
	(2.30)
M10	45.51
	(4.08)
W10	32.88
	(1.80)

N=1001

TABLE 3
TAAS Reading Achievement
Unstandardized and (Standardized) Coefficients

SIZE	0.177 (.065)
PCTPOOR	-0.040*** (-.367)
PCTBLACK!	-0.253*** (-.142)
PCTHISP	-0.010** (-.123)
PCTLEP!	-0.268** (-.117)
S/TRATIO	- 0.008 (-.011)
EPP	0.027 (.015)
PCTINST	0.007 (.022)
UNIT	0.733** (.102)
PCTTECH	0.004 (.040)
PCTSPECL	0.047** (-.123)
PCTGIFT	0.038** (.118)
SIZE-by-SES	-0.035** (-.143)
Adjusted R-Squared	40.3%
	N=1001

*** <.001
** <.01
* <.05
! Expressed as Natural Logarithms

Partial Derivative = -0.035(PCTPOOR)

Effect Size Points (S.D. Units)	PCTPOOR (Quartiles)
-0.76 (-0.33)	21.6%
-1.14 (-0.50)	32.5%
-1.73 (-0.75)	49.5%
-3.50 (-1.52)	100.0%

TABLE 4
TAAS Math Achievement
Unstandardized and (Standardized) Coefficients

SIZE	0.019 (.040)
PCTPOOR	-0.062*** (-.318)
PCTBLACK!	-0.631*** (-.200)
PCTHISP	-0.022** (-.152)
PCTLEP!	0.010 (.002)
S/TRATIO	-0.146** (-.113)
EPP	-0.149 (-.048)
PCTINST	0.007 (.013)
UNIT	0.611 (.048)
PCTTECH	0.005 (.024)
PCTSPECL	-0.064** (-.095)
PCTGIFT	0.052** (.090)
SIZE-by-SES	-0.060** (-.144)
Adjusted R-Squared	30.5%
	N=1001

*** <.001
** <.01
* <.05
! Expressed as Natural Logarithms.

Partial Derivative = -0.060(PCTPOOR)

Effect Size Points (S.D. Units)	PCTPOOR (Quartiles)
-1.30 (-0.32)	21.6%
-1.95 (-0.48)	32.5%
-2.97 (-0.73)	49.5%
-6.00 (-1.47)	100.0%

TABLE 5
TAAS Writing Achievement
Unstandardized and (Standardized) Coefficients

SIZE	0.052 (.025)
PCTPOOR	-0.031*** (-.366)
PCTBLACK!	-0.183*** (-.132)
PCTHISP	-0.002 (-.037)
PCTLEP!	-0.310*** (-.173)
S/TRATIO	-0.041 (-.072)
EPP	-0.007 (-.006)
PCTINST	0.007 (.027)
UNIT	0.505** (.090)
PCTTECH	-0.001 (-.010)
PCTSPECL	-0.036*** (-.123)
PCTGIFT	0.027** (.105)
SIZE-by-SES	-0.033*** (-.171)
Adjusted R-Squared	40.3%
	N=1001

*** <.001
** <.01
* <.05
! Expressed as Natural Logarithms.

Partial Derivative = -0.033(PCTPOOR)

Effect Size Points (S.D. Units)	PCTPOOR (Quartiles)
-0.71 (-0.40)	21.6%
-1.07 (-0.60)	32.5%
-1.63 (-0.91)	49.5%
-3.30 (-1.84)	100.0%

TABLE 6
Unit Schools and Expenditure Per Pupil!!
Unstandardized and (Standardized) Coefficients

SIZE!	-254.415***
	(-.199)
PCTPOOR	-4.158
	(-.066)
PCTBLACK!	81.239**
	(.080)
PCTHISP	5.668**
	(.119)
PCTLEP!	37.920
	(.029)
S/TRATIO	-284.614***
	(-.680)
PCTINST	-35.422***
	(-.199)
PCTTECH	-2.923
	(-.046)
PCTSPECL	1.291
	(.006)
PCTGIFT	4.823
	(.026)
COMPOSITE	-3.551
	(-.008)
UNIT	-1017.607***
	(-.247)
UNIT-by-SIZE	-730.195***
	(-.172)
Adjusted R-Squared	51.4%
	N=1001

*** <.001
** <.01
* <.05
! Expressed as Natural Logarithms.
!! Weighted for differences in mean EPP by grade level.

Partial Derivative = -254.415(1/SIZE) - 730.195(UNIT)(1/SIZE)

Effect Size (Dollars) UNIT=1	UNIT=0	SIZE (Quartiles)
-4.48	-1.16	220
-2.20	-0.57	447
-0.67	-0.17	1459
-0.22	-0.06	4434

TABLE 7
One High School, Grade Levels, and Expenditure Per Pupil!!
Unstandardized and (Standardized) Coefficients

SIZE!	-290.519***
	(-.227)
PCTPOOR	-2.927
	(-.046)
PCTBLACK!	35.476
	(.035)
PCTHISP	4.160*
	(.088)
PCTLEP!	23.216
	(.018)
S/TRATIO	-314.462***
	(-.751)
PCTINST	-34.101***
	(-.191)
PCTTECH	-3.365
	(-.053)
PCTSPECL	1.318
	(.006)
PCTGIFT	0.646
	(.003)
COMPOSITE	8.725
	(.019)
HIGHSKLS!	332.023***
	(.223)
LEVELS	-98.358**
	(-.232)
HIGHSKLS-by-SIZE	-114.038*
	(-.076)
LEVELS-by-SIZE	-48.445**
	(-.108)
Adjusted R-Squared	52.8%
	N=1001

*** <.001
** <.01
* <.05
! Expressed as Natural Logarithms.
!! Weighted for differences in mean EPP by grade level.

Partial Derivative = - 290.519(1/SIZE)
- 114.038(HIGHSKLS)(1/SIZE) - 48.445(LEVELS)(1/SIZE)

Effect Size (Dollars)	SIZE (Quartiles)	HIGHSKLS (Quartiles)	LEVELS (Quartiles)
-2.20	220	0	4
-1.08	447	0	4
-0.41	1459	0.69	6
-0.31	4434	3.26	15

TABLE 8
High Schools Per District

1	2	3	4	5	6	8	10	12	21	26
92.49% (727)	3.69% (29)	1.14% (9)	1.27% (10)	0.76% (6)	0.51% (4)	0.25% (2)	0.25% (2)	0.13% (1)	0.13% (1)	0.13% (1)

TABLE 9
Grade Levels Per High School

2	3	4	5	6	7	9	12	13	14	15
0.50% (5)	1.80% (18)	72.43% (725)	0.80% (8)	11.09% (111)	1.70% (17)	0.09% (1)	0.09% (1)	5.79% (58)	3.70% (37)	2.00% (20)

TABLE 10
Composite Achievement
Unstandardized and (Standardized) Coefficients

SIZE!	0.218 (.079)
PCTPOOR	-0.054*** (-.403)
PCTBLACK!	-0.270*** (-.123)
PCTHISP	-0.008 (-.081)
PCTLEP!	-0.255* (-.090)
S/TRATIO	0.017 (.019)
PCTINST	0.004 (.011)
PCTTECH	0.001 (.009)
PCTSPECL	-0.056*** (-.121)
PCTGIFT	0.051*** (.130)
HIGHSKLS!	-0.946*** (-.297)
LEVELS	0.130** (.142)
HIGHSKLS-by-SIZE	0.534*** (.166)
LEVELS-by-SIZE	0.050 (.051)
SIZE-by-SES	-0.034* (-.116)
Adjusted R-Squared	42.7%
	N=1001

*** <.001
** <.01
* <.05
! Expressed as Natural Logarithms.

Partial Derivative = 0.534(HIGHSKLS)(1/SIZE) - 0.034PCTPOOR)

Effect Size Points (S.D. Units)	SIZE (Quartiles)	HIGHSKLS (Quartiles)	PCTPOOR (Quartiles)
-0.73 (-0.26)	220	0	21.6
-1.10 (-0.39)	447	0	32.5
-1.68 (-0.59)	1459	0.69	49.5
-3.39 (-1.20)	4434	3.26	100.0

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